

Congressional Notification Profile

DE-PS26-02NT41369

UNIVERSITY COAL RESEARCH PROGRAM, INNOVATIVE CONCEPTS PROGRAM

Drexel University

Background and Technical Information:

Project Title: "Ultrasensitive High-Temperature Selective Gas Detection Using Piezoelectric Microcantilevers."

This project proposes to develop an ultrasensitive, high-temperature device to detect and characterize carbon dioxide concentrations on a biomolecular level in coal-derived flue gas streams with temperatures reaching 1,000° C and higher. In a separate proposal, the university would separate CO₂ from nitrogen. Once CO₂ selection is demonstrated, the device would be used to detect sulfur dioxide and nitrogen oxide.

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Congressional District: 02 District County: Philadelphia

Financial Information:

Length of Contract (months): 12

Government Share: \$50,000

Total value of contract: \$50,000

DOE Funding Breakdown:

Funds: FY 2002 \$50,000

Public Abstract

Proposal Title: Ultrasensitive High-Temperature Selective Gas Detection Using Piezoelectric Microcantilevers

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Institution: Drexel University, Philadelphia, Pennsylvania

Proposal Category: UCR Innovative Concepts Phase-I Program ON Smart Sensing and Advanced Artificially Intelligent Control Systems

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Objective: The objective of proposed program of research is to use highly piezoelectric microcantilevers for *in-situ, rapid, selective* gas detection with femtogram sensitivity (10^{-15} g). The proposed piezoelectric microcantilevers with mesoporous oxide coating at the cantilever tip will selectively measure the presence of gas molecules with femtogram sensitivity. The potential for detection of gas molecules in very dilute concentrations is greatly enhanced by suitably engineering the piezoelectric device in a cantilever form.

The device consists of a piezoelectric cantilever smaller than 20 μm in length coupled to a mesoporous oxide coating at the cantilever tip. Selective gas adsorption is facilitated by properly doping the mesoporous oxide coating. Binding of target gas molecules is detected by monitoring the resonance frequency shift. The proposed piezoelectric cantilever allows an unprecedented sensitivity, better than 10^{-15} g/Hz.

Methodology: (1) We have shown that lead zirconate titanate (PZT)/steel cantilevers can be used as a liquid viscosity and density sensor, mass sensor, in-water bioagent detector, and liquid-solid transition detector. Currently we are developing highly piezoelectric lead magnesium niobate-lead titanate solid solutions, $\text{PMN}_{0.65}\text{-PT}_{0.35}$, microcantilevers for in-water biomolecular detection (a NSF project) and for in-water pathogen detection (an EPA project). This approach will be extended to selectively detect gases at high temperatures. For high temperature applications, we have successfully fabricated pyrochlore-free piezoelectric PT thin layers with a novel sol-gel approach. PT has a high Curie temperature (490°C) and can be operative up to 490°C . In Phase I, we will integrate PT-based thin layers with current microelectronic devices to fabricate the microcantilevers. Lithium niobate (LN) has a Curie temperature of 1142°C . In Phase II, we will extend the approach to fabricate LN-based microcantilevers that can operate above 1000°C .

(2) We have shown that Ba-doped mesoporous alumina (BDMA) can selectively adsorb CO_2 . In a separate proposal we propose to couple the selective CO_2 adsorption property of Ba-doped oxides with 0.6 nm micropores to separate CO_2 from N_2 . In this proposal, we will couple highly piezoelectric cantilevers with BDMA coated at the cantilever tip for selective CO_2 detection. The

resonance frequency shift transient as well as the saturated resonance frequency shift will be used to characterize the CO₂ concentration. Once selective CO₂ detection is demonstrated, similar approaches can be taken for selective SO₂ and NO_x detection.